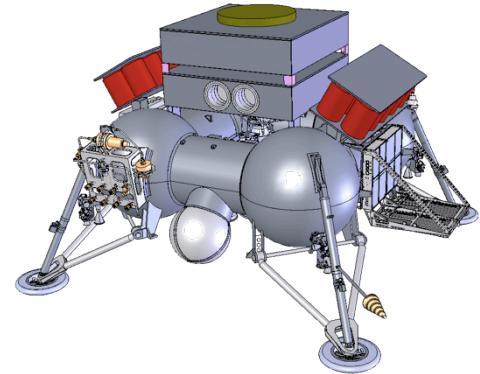
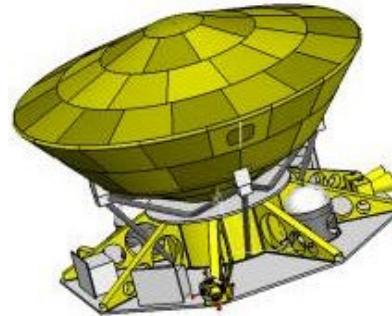
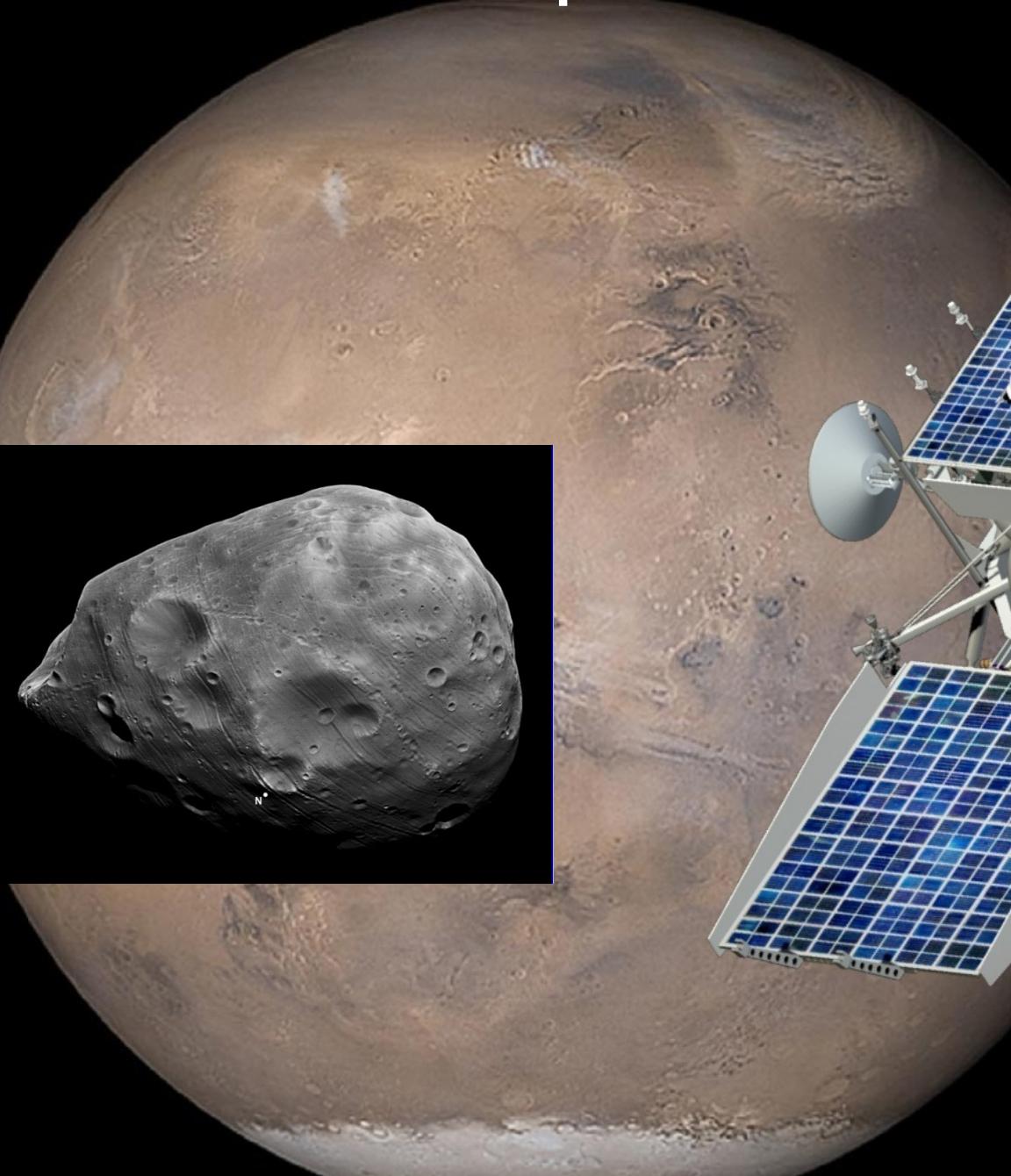


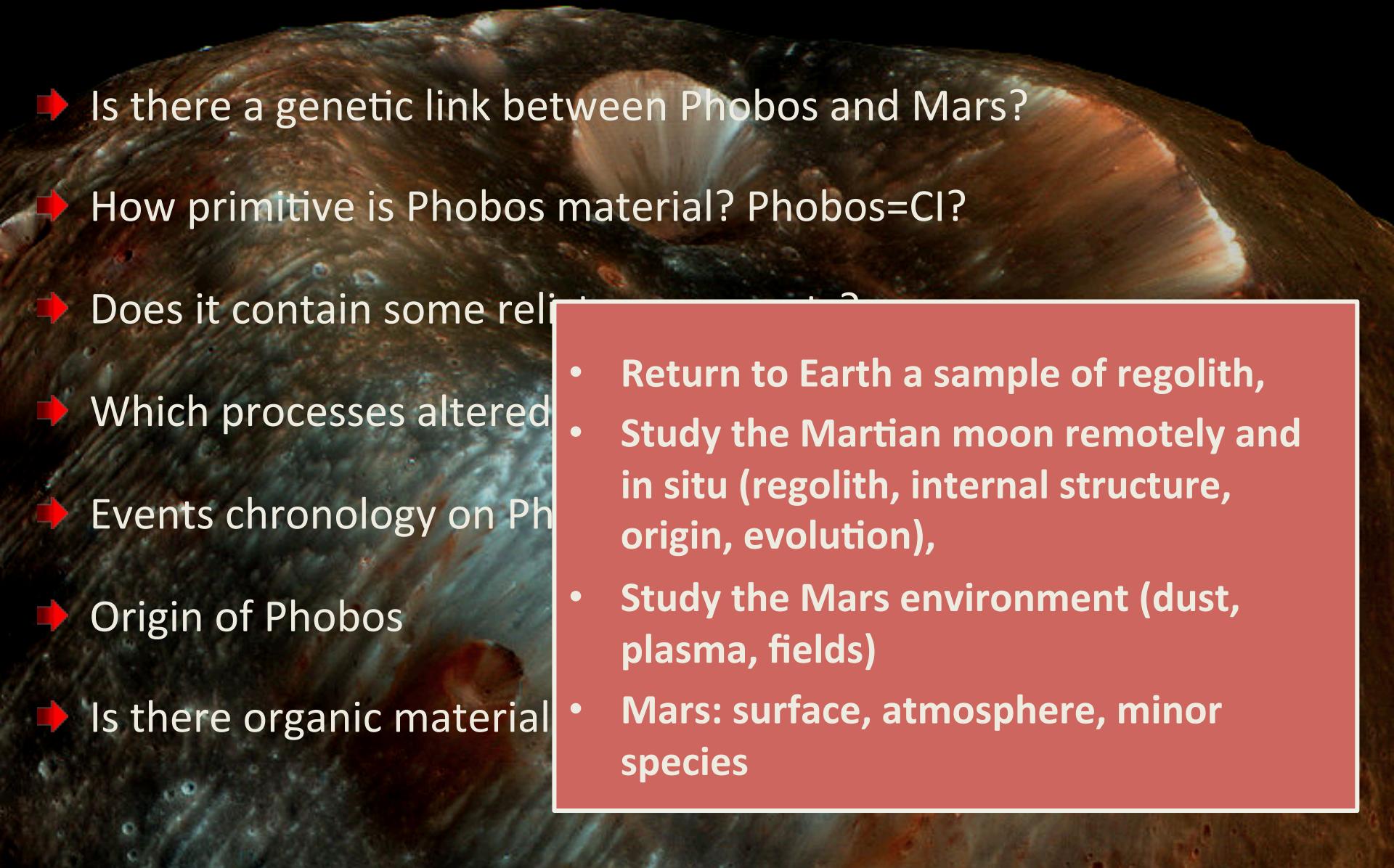
Outlook for planetary probe missions in Russia



Phobos Sample Return (2011)



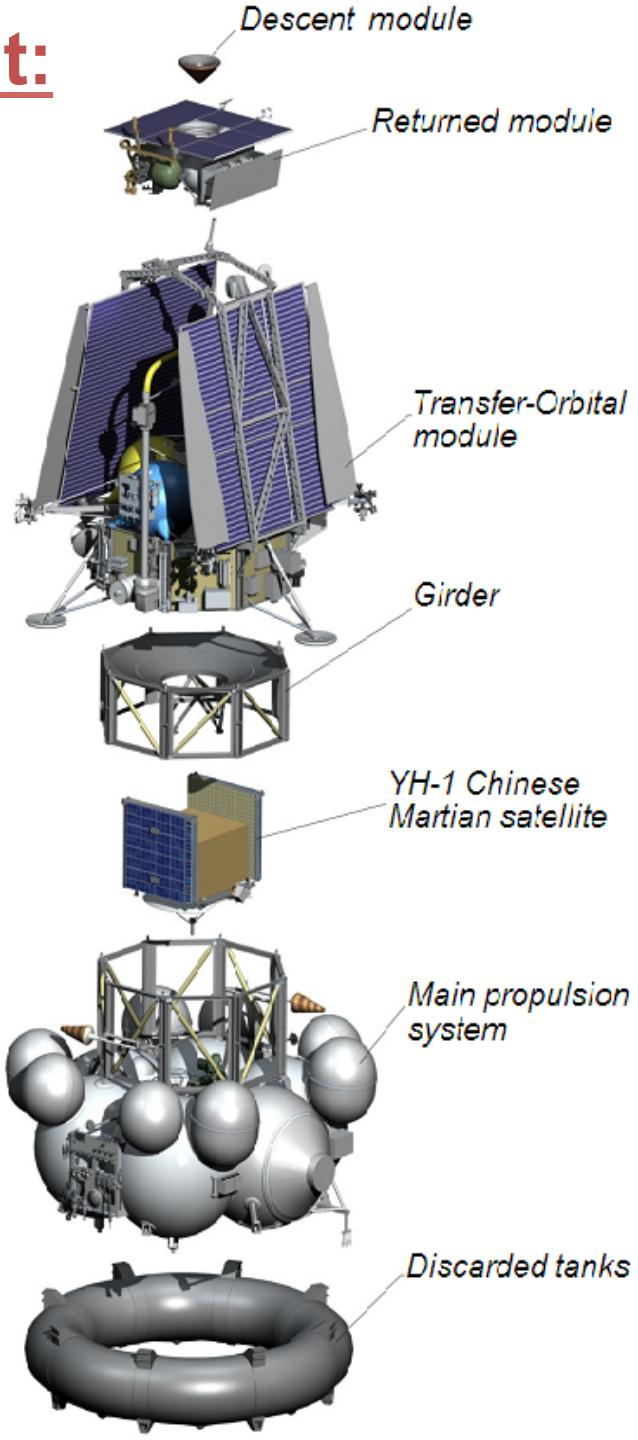
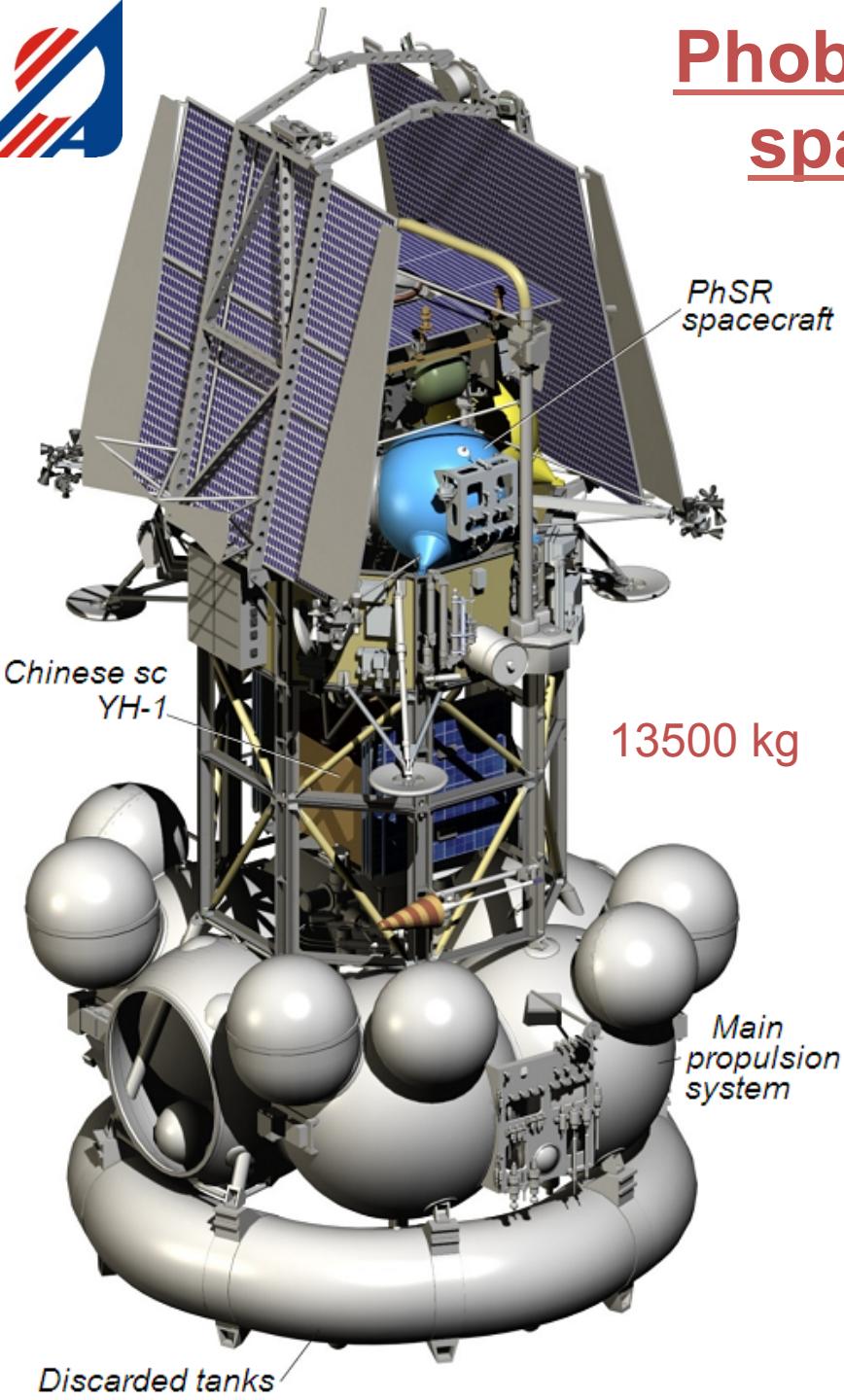
Science questions to Phobos

- 
- ➡ Is there a genetic link between Phobos and Mars?
 - ➡ How primitive is Phobos material? Phobos=CI?
 - ➡ Does it contain some relatively young material?
 - ➡ Which processes altered the material?
 - ➡ Events chronology on Phobos?
 - ➡ Origin of Phobos
 - ➡ Is there organic material?

- **Return to Earth a sample of regolith,**
- **Study the Martian moon remotely and in situ (regolith, internal structure, origin, evolution),**
- **Study the Mars environment (dust, plasma, fields)**
- **Mars: surface, atmosphere, minor species**

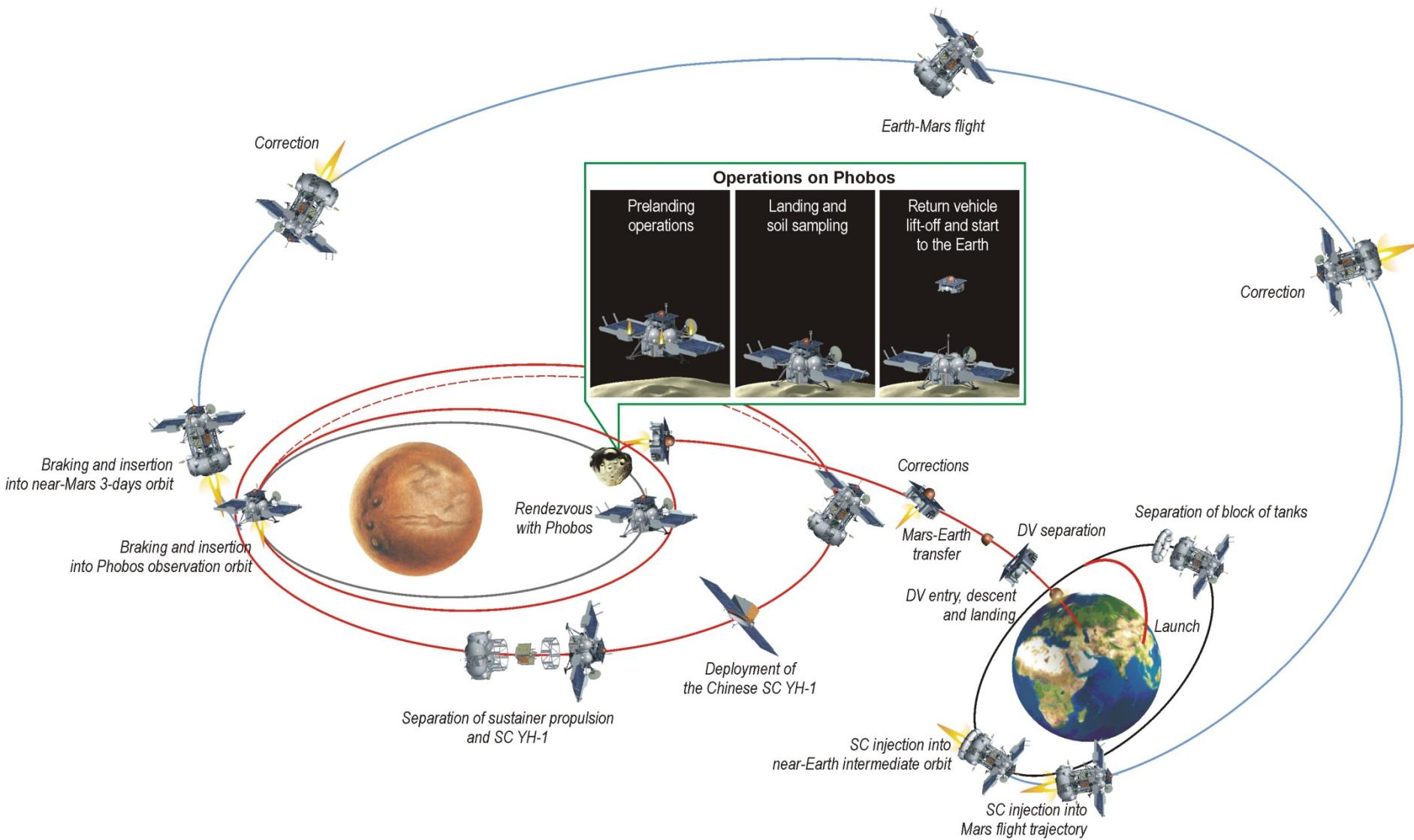


Phobos-Grunt: spacecraft



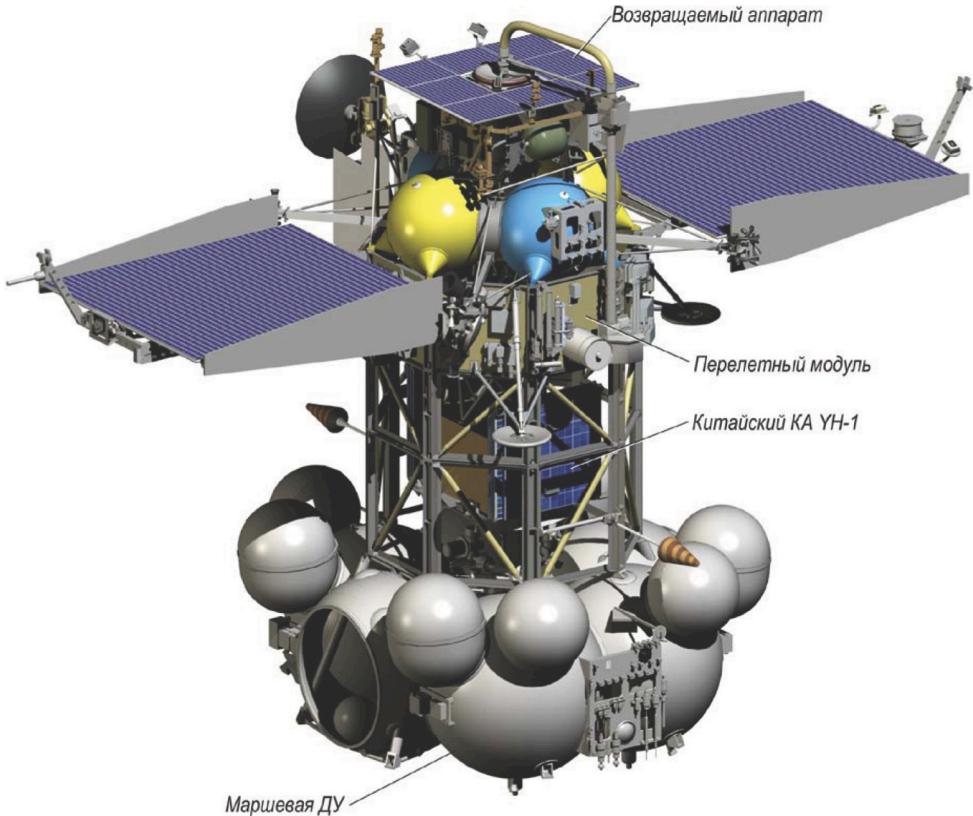


Mission Profile





Spacecraft Modules and phases of the mission



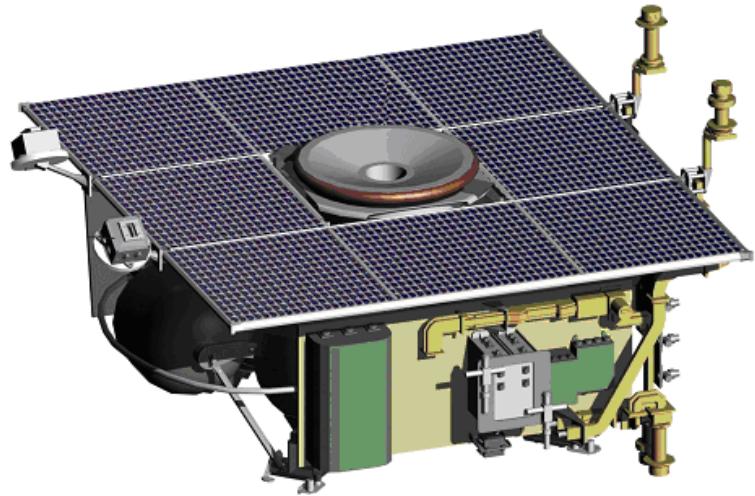
Interplanetary cruise (~5700 kg)



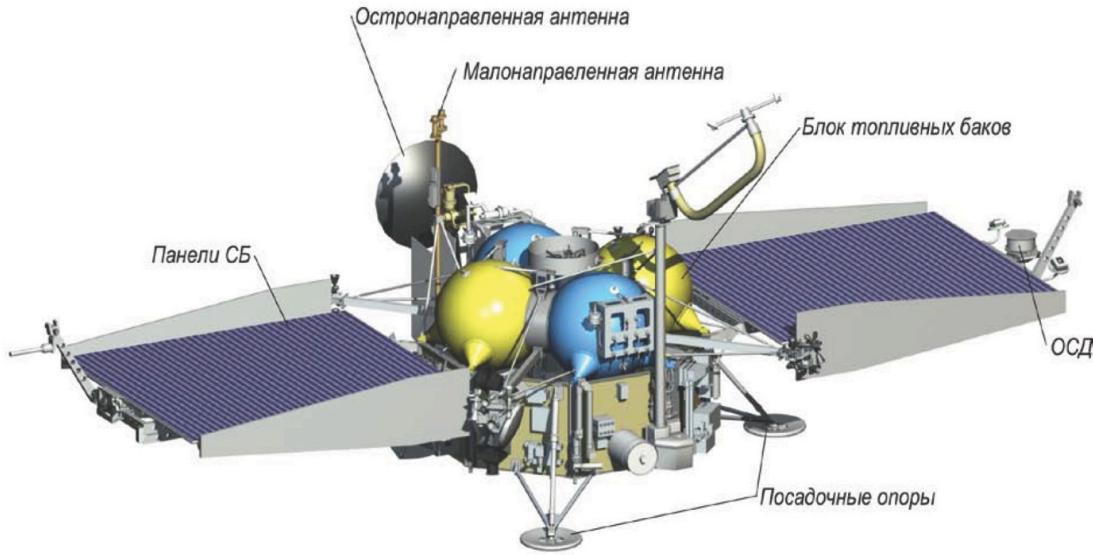
Approach Phobos and landing
(1250 kg)



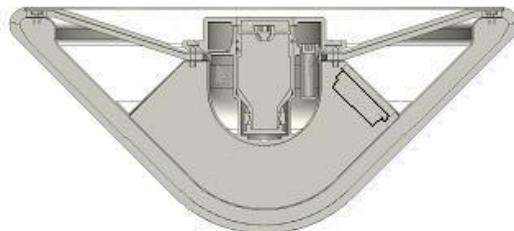
Spacecraft Modules and phases of the mission



Mars-Earth interplanetary flight (296 kg)



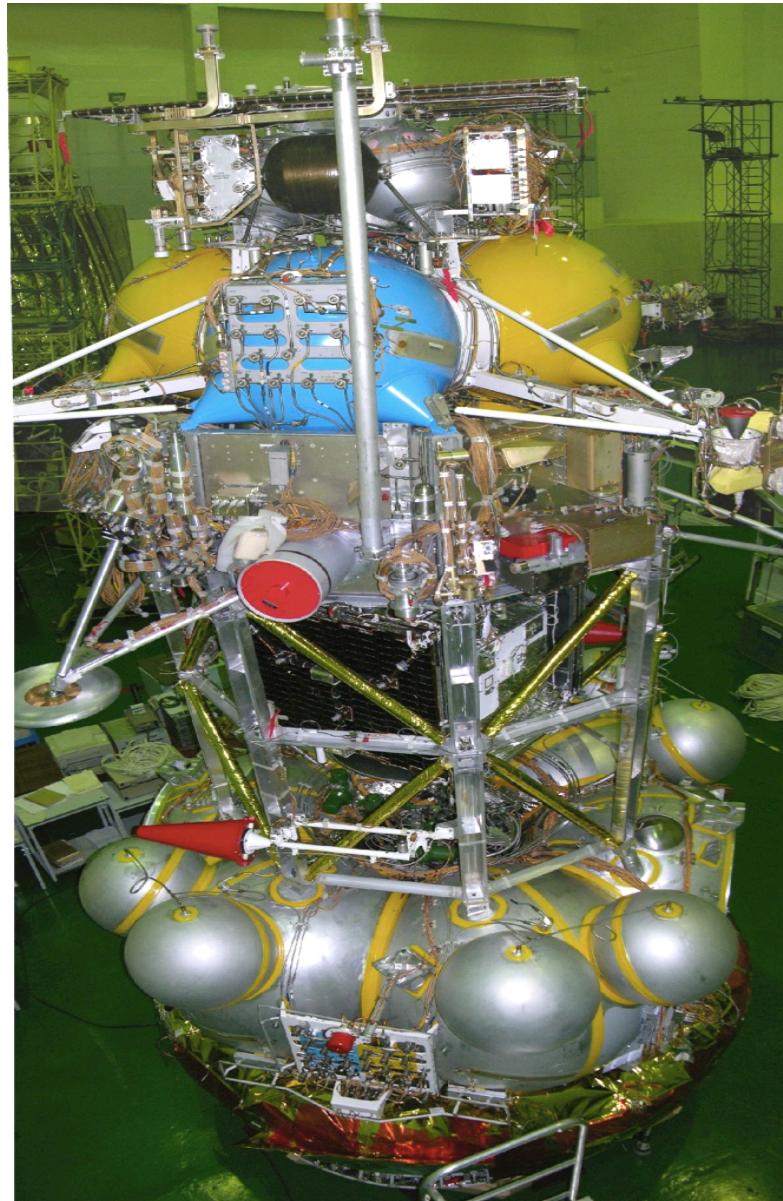
At Phobos surface after take off the Return Module



The Descent module (7.5 kg)



Phobos: Integrated Flight Spacecraft

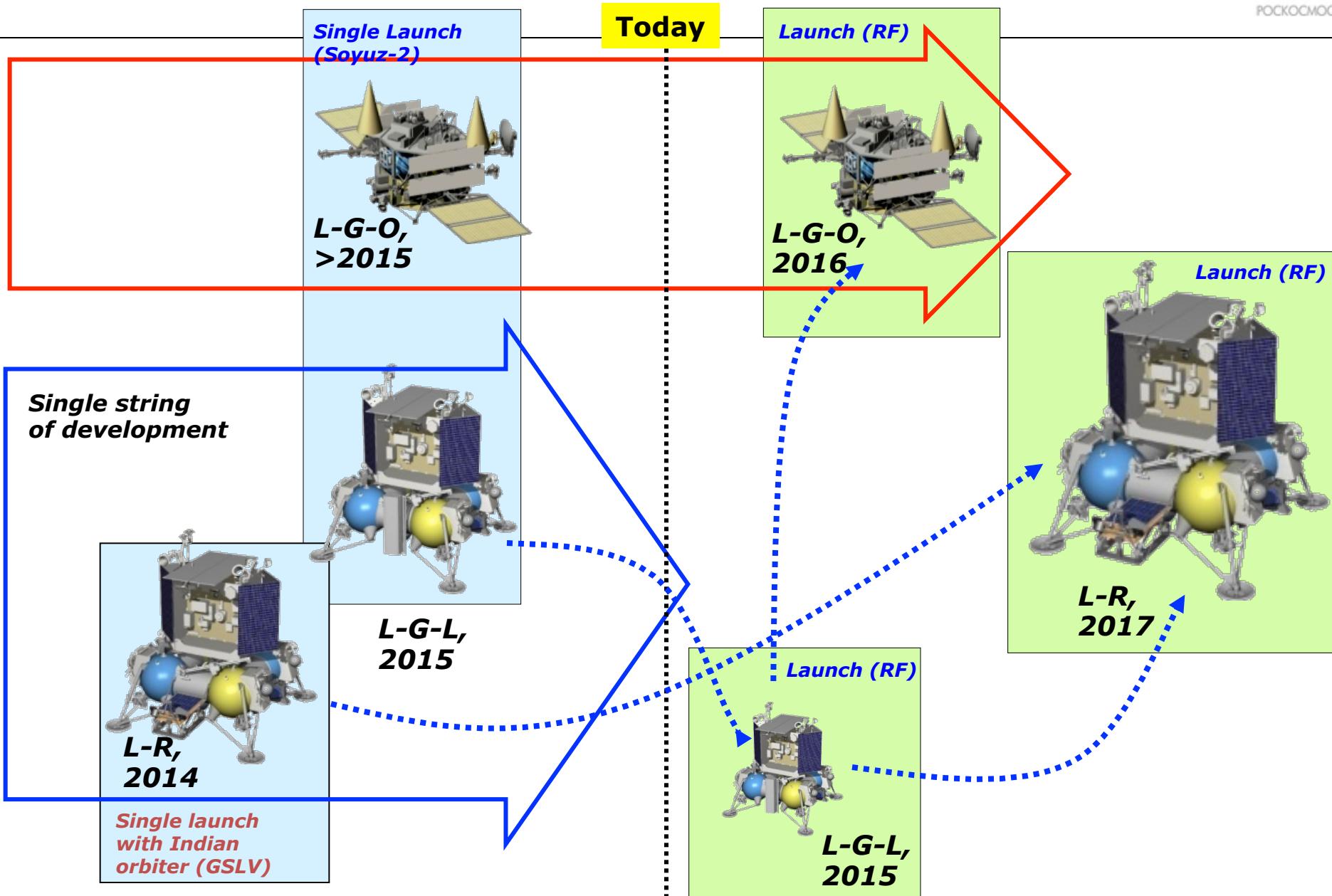


Lunar Program: Projects and Perspectives



Project	Concept	Science goals	Exploration goals
Luna Glob Lander 2015	Small Lander on the TBD pole	Analysis of lunar regolith and local exosphere, testing volatiles from <50 cm subsurface	Re-development of lunar landing system, communication system, long-time operations
Luna Glob Orbiter 2016	Orbiter at 100 km polar circular orbit	Global mapping of lunar surface, measurements of exosphere and plasma around Moon	Reconnaissance of landing sites for lunar exploration, long-time orbital operations, global mapping
Luna Resource 2017 (cooperation with India)	Large Lander on the south pole	Analysis of lunar regolith and local exosphere, testing volatiles from >2 meters cm subsurface	Testing of Drilling system for cryogenic sampling; Joint operations of Rover with Lander
Luna Resource – 2 > 2018	Lunokhod (Large Long Distance Moon Rover)	Studies of lunar surface at distance of about 30 km, cryogenic sampling of subsurface soil with volatiles	Mobility on the Moon surface, long duration mission with solar and radioisotopic power, cryogenic cashing of samples
Polar Moon Sample Return > 2020	Lander with return rocket	Cryogenic delivery of samples form Lunokhod to the Earth	Surface operations of Lunokhod with Lander, re-development of return flight system Moon-Earth

Modification of Lunar Program

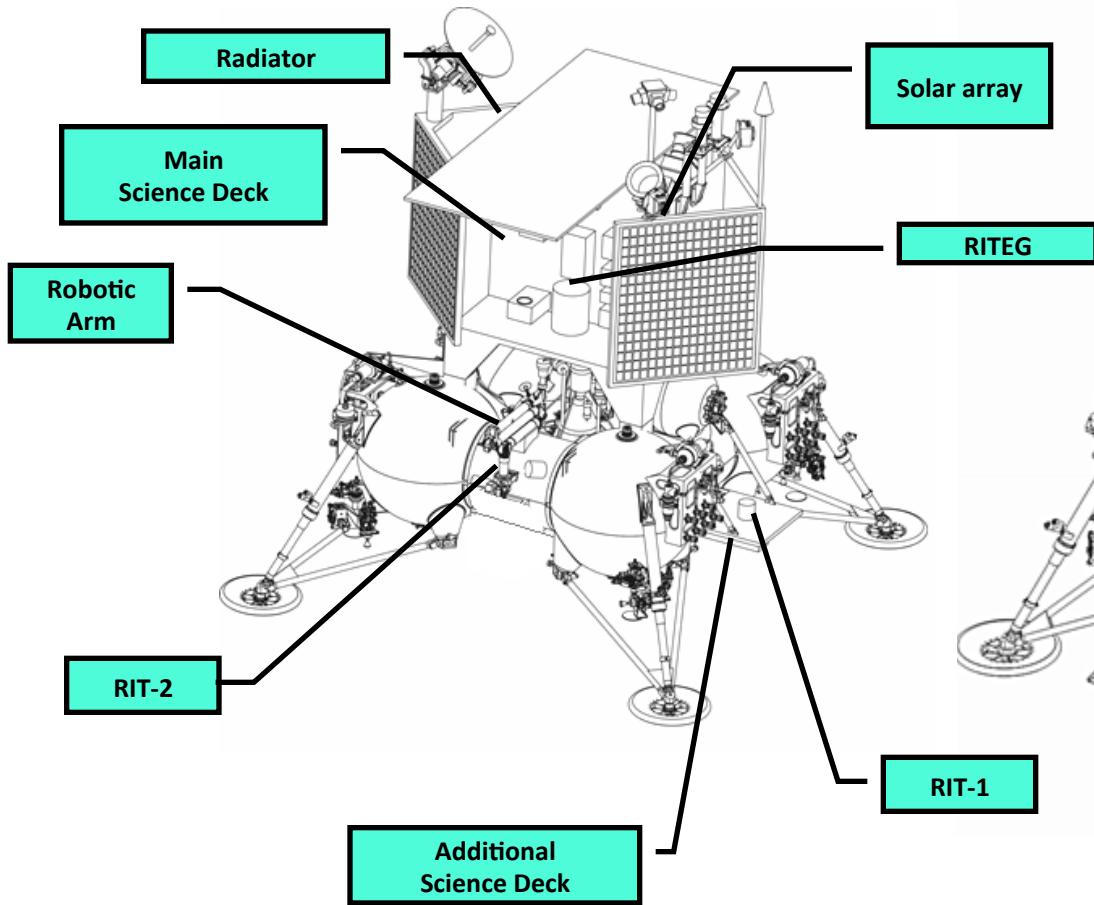




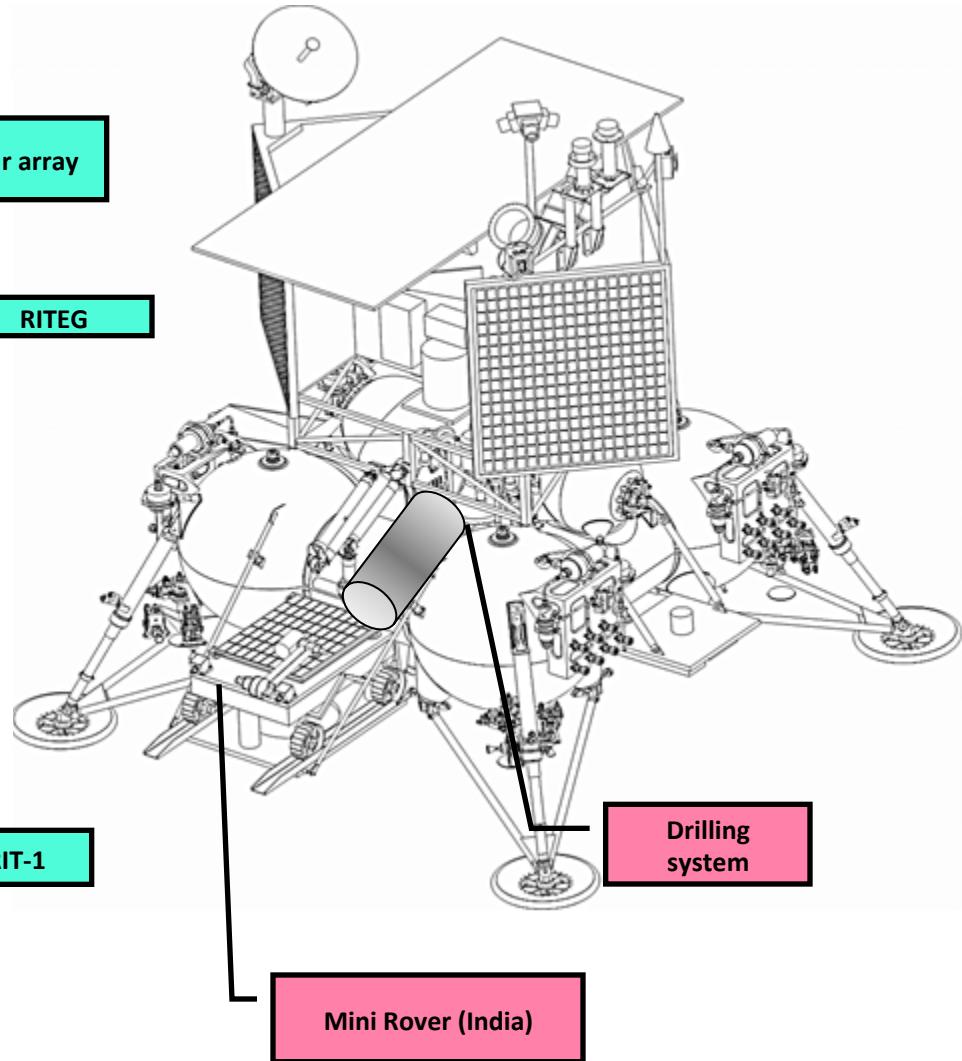
MOON: Luna Glob and Luna Resource Landers



LUNA-Glob 2015



LUNA-Resource 2017



MOON: Science payload of Lunar Landers 15/17

Instrument	Measurements	Mass (kg)	Accommodation	PI Organization
Radio-Beacon	Radio signal with very high stability	1,7	Main_SD	IKI
TVRPM (TV for R-Arm)	TV imaging of nearest area and objects (for Robotic arm aiming too)	0,5	R_Arm	IKI
LIS	IR spectrometry of minerals	1,0	R_Arm	IKI
Analytic complex	Chromatographic and mass spectroscopy analysis of volatiles content and chemical composition	10,4	Main_SD	IKI+U of Bern
LASMA	Laser mass-spectrometer	2,8	Main_SD	IKI+U of Bern
TV-Spectrometer	UV and optical imaging of minerals with UV excitation	0,5	Main_SD	IKI
ADRON	Active neutron and gamma-ray analysis of regolith composition	6,7	Add_SD	IKI
RAT	Radio measurements of temperature of subsurface regolith	0,5	Add_SD	IKI
PML	Measurements of dust and micrometeotits	1,5	Add_SD	IKI
SEISMO	Measurements of seismic activity	1,0	Main_SD	IFZ (Schmidt)
ARIES (<u>L-R</u> only)	Measurements of plasma and neutrals	2,2	Main_SD	IKI
TERMO (<u>L-G</u> only)	Direct measurements of thermal properties of regolith	2,0	Main_SD	GEOKHI (Vernadsky)
LINA (<u>L-G</u> only)	Measurements of plasma and neutrals	4,6	Main_SD	IKI+IRF (Kiruna)
TV for panorama	TV imaging of panoramas and area near Lander	2	Main_SD	IKI
TV for stereo	(rover and Robotic arm)			
Retro Reflector	Moon libration and ranging experiment	1	Main_SD	NPO SPP

EXOMARS: Participation in ESA-led mission



1. Proton launch of 2016 composite

- ~~RTG and Russian instruments on EDM~~ **Cancelled on 8 June**
- Russian instruments on TGO
- Joint science programme

2. Proton launch of 2018 probe

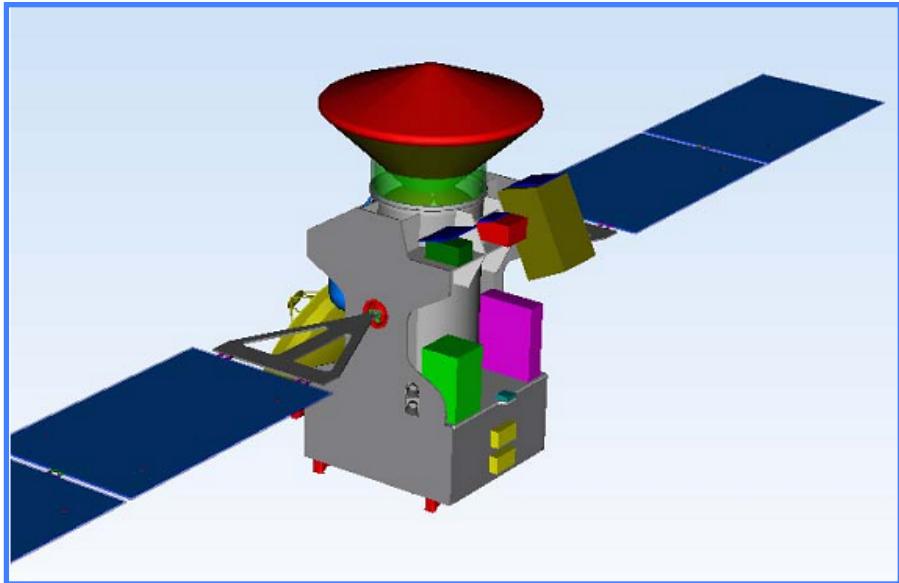
- Roscosmos-led Descent Module using experience of EDM and lunar descents
- ESA-supplied s/systems for the DM
- Roscosmos-led fixed long-living platform (target science payload 50 kg)



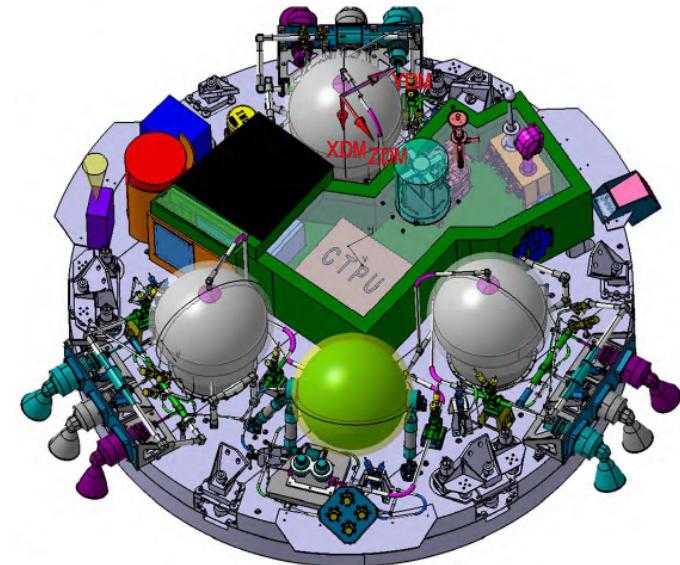
ExoMars: Project configuration

2016

TGO: Trace Gas Orbiter

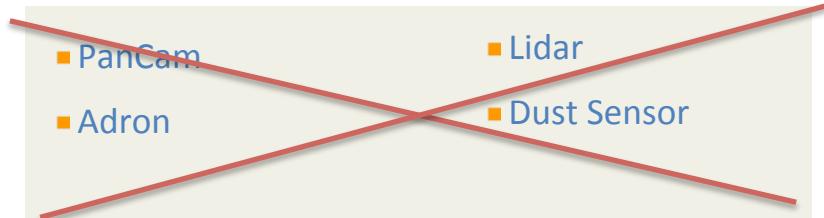


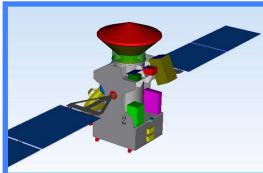
EDM: Entry, Descent & Landing Demonstrator Module



Russian participation

- ACS: 3 spectrometers and electronic block
- FREND: Collimated neutron spectrometer + dosimeter



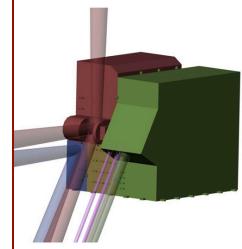


ExoMars: Trace Gas Orbiter

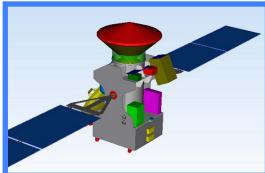
Russian contribution: ACS



Atmospheric Chemistry Suite (ACS) – Three spectrometers for the study of atmospheric chemistry and climate. Total mass: 33.3 kg (with electronic block).



Name	Description	Prototype
ACS-NIR	Echelle-AOTF (Near IR: 0.7-1.7 μm, R~20000). Monitoring and profiling of CO, H ₂ O, O ₂ . Dayglow O ₂ emission, sensitive search for nightglows. Mass: 3.5 kg. Power: 15 W.	ISS
ACS-MIR	Echelle spectrometer (Middle IR: 2.2-4.5 μm, R>50000). Profiles of CH ₄ , H ₂ O, CO, isotopic ratios HDO/H ₂ O. Search for undetected phases. Mass: 12 kg. Power: 20 W.	Phobos-Grunt
ACS-TIR	Fourier-spectrometer (2-25 μm, 0.2 cm ⁻¹). Monitoring of thermal state, aerosols, minor constituents in nadir. Detection in occultation. Mass: 12 kg. Power: 20 W.	Phobos-Grunt

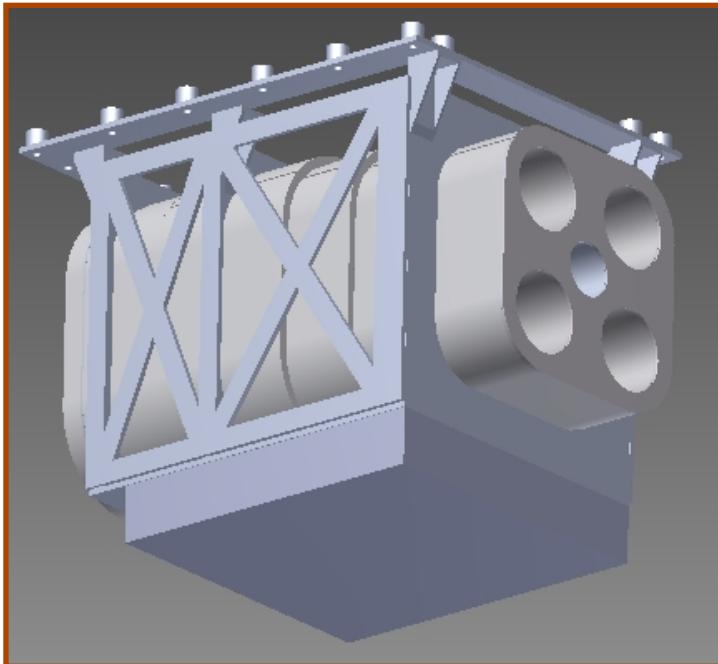


ExoMars: Trace Gas Orbiter

Russian contribution: FREND



Fine Resolution Epithermal Neutrons Detector (FREND) – a neutron detector with a collimation module that significantly narrows the field of view of the instrument, thus allowing to create higher resolution maps of hydrogen-abundant regions on Mars. Additionally, dosimeter module for monitoring of radiation levels is installed.



Energy ranges:

Epithermal neutron detectors: 0.4 eV – 500 keV

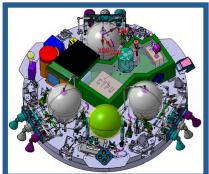
Fast neutron detector: 0.5 – 10 MeV

Time resolution: 5 s

Spatial resolution: ~ 40 km from 400 km orbit: 10 times better than HEND (Mars-Odyssey)

Mass: 36 kg

Power: 11W



ExoMars: EDM 2016

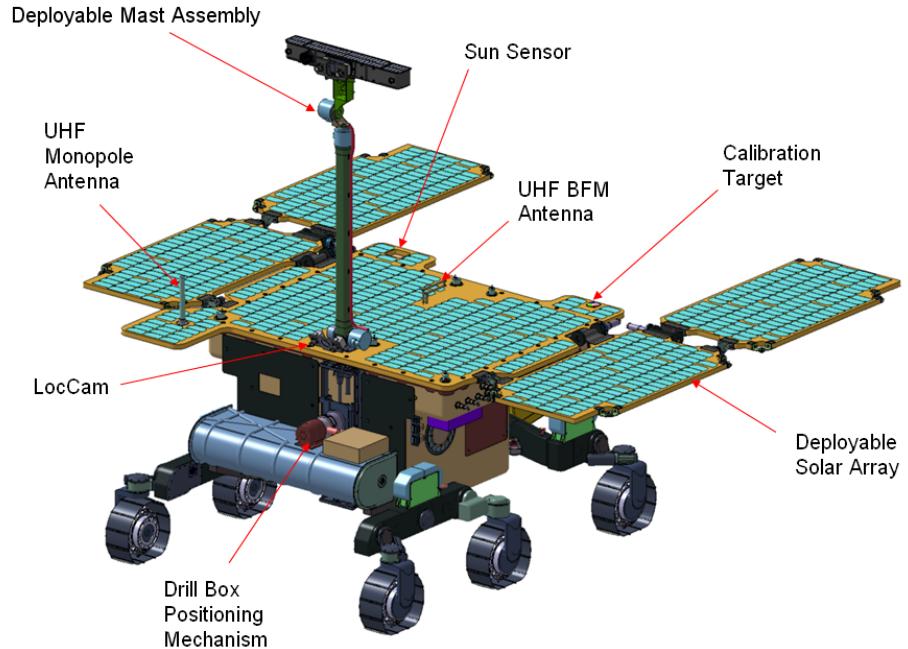
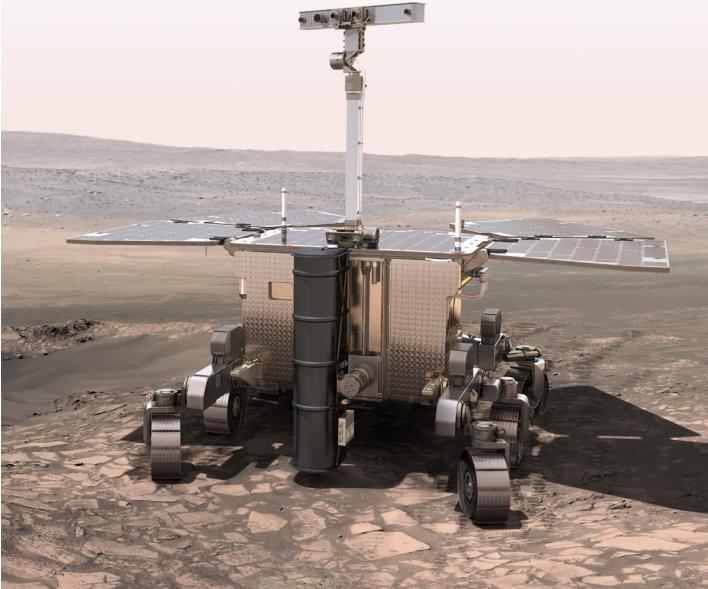
Russian contribution

Name	Description	Prototype
PanCam	Color panoramas of the surface around EDM to define geological context, assess the mineralogical composition of surrounding rocks and soil, and determine the exact location of EDM. Monitoring of atmospheric phenomena (clouds, fogs, dust devils, etc.). Mass: 1.1 kg. Power: 5 W	Phobos-Grunt/Luna-Resurs
ADRON EDM	Neutron detector and dosimeter. Search for subsurface water and monitoring of radiation levels. Mass: 1,5 kg. Power: 6 W.	MSL
LIDAR	Measuring of day and season dynamics of vertical structure of near-the-surface aerosol and water vapor in the Mars atmosphere up to the altitude of 10 km. Studying of the process of formation of clouds and near-the-surface. Mass: 0.55 kg. Power: 5 W.	Mars Polar Lander
Dust Sensor	Dust particles dynamics near the surface.. Mass: 0.65 kg. Power: 4 W.	Luna-Resurs

ExoMars: Project configuration

2018

Exomars Rover with Pasteur payload Landing Platform

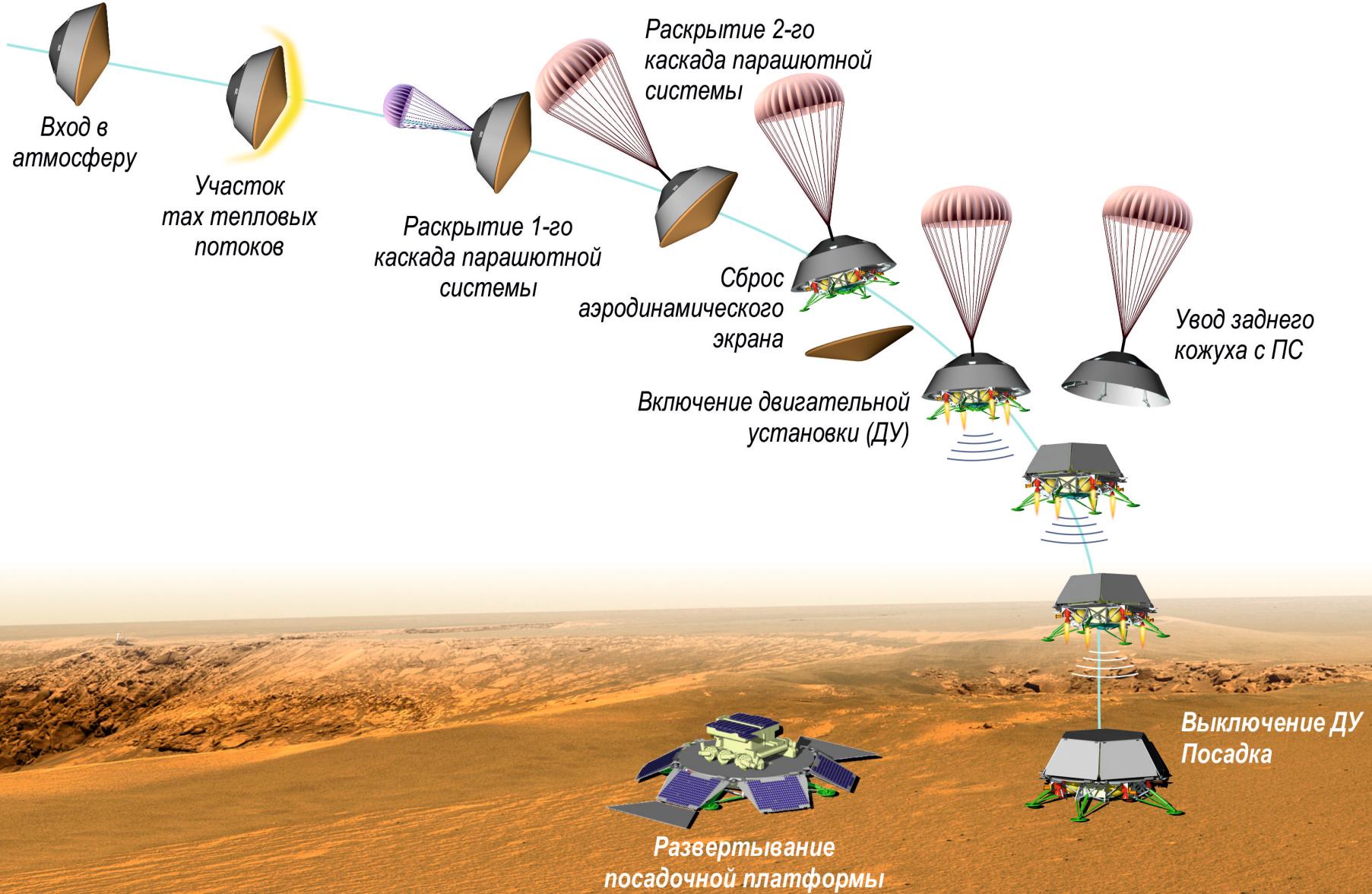


Russian contribution:

- Two instruments onboard of the rover: Infrared spectrometer (ISEM) on the mast and neutron detector Adron-RM.
- Scientific payload of the landing platform.

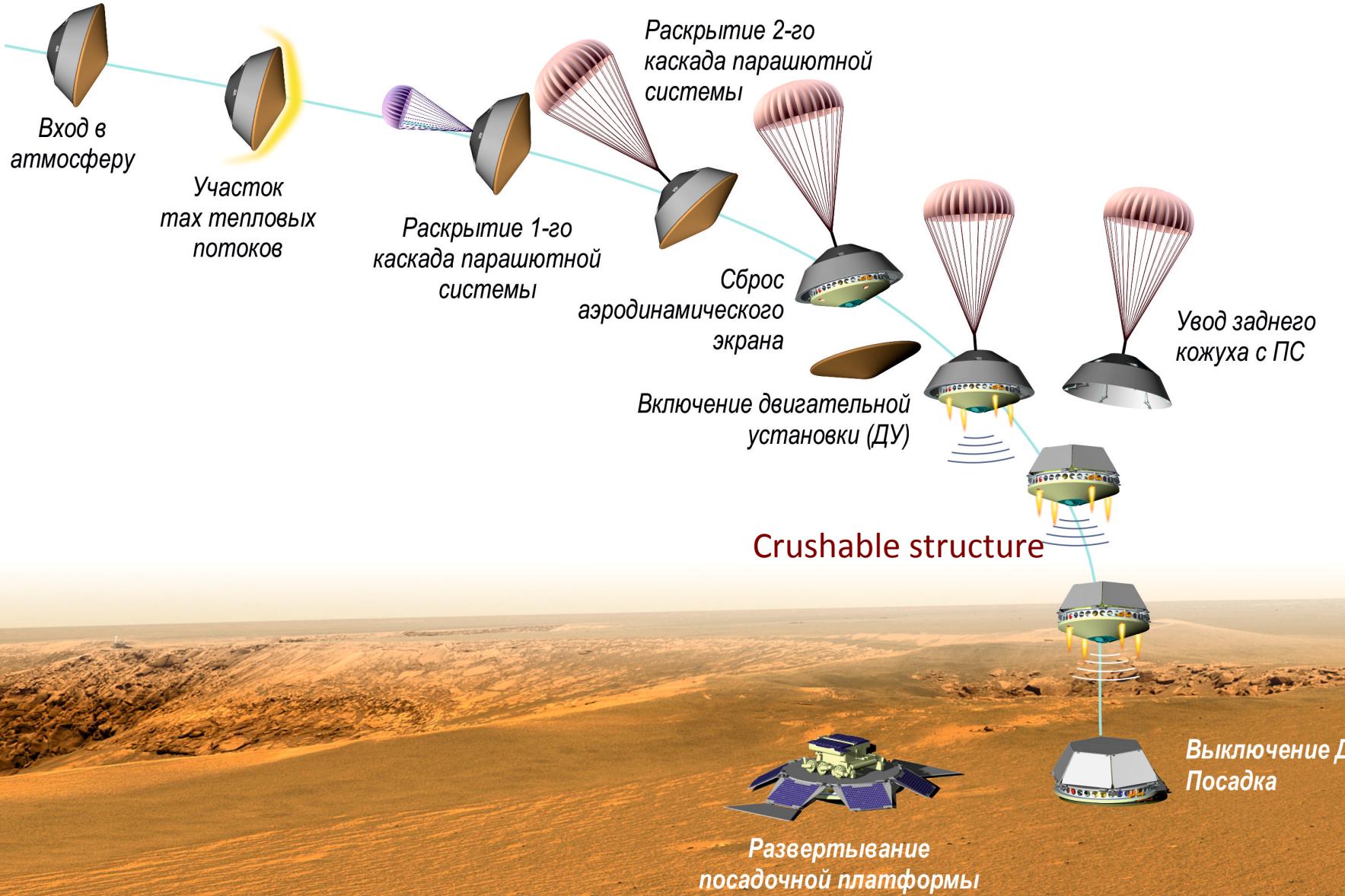


EXOMARS 2018: Descent Scenario 1



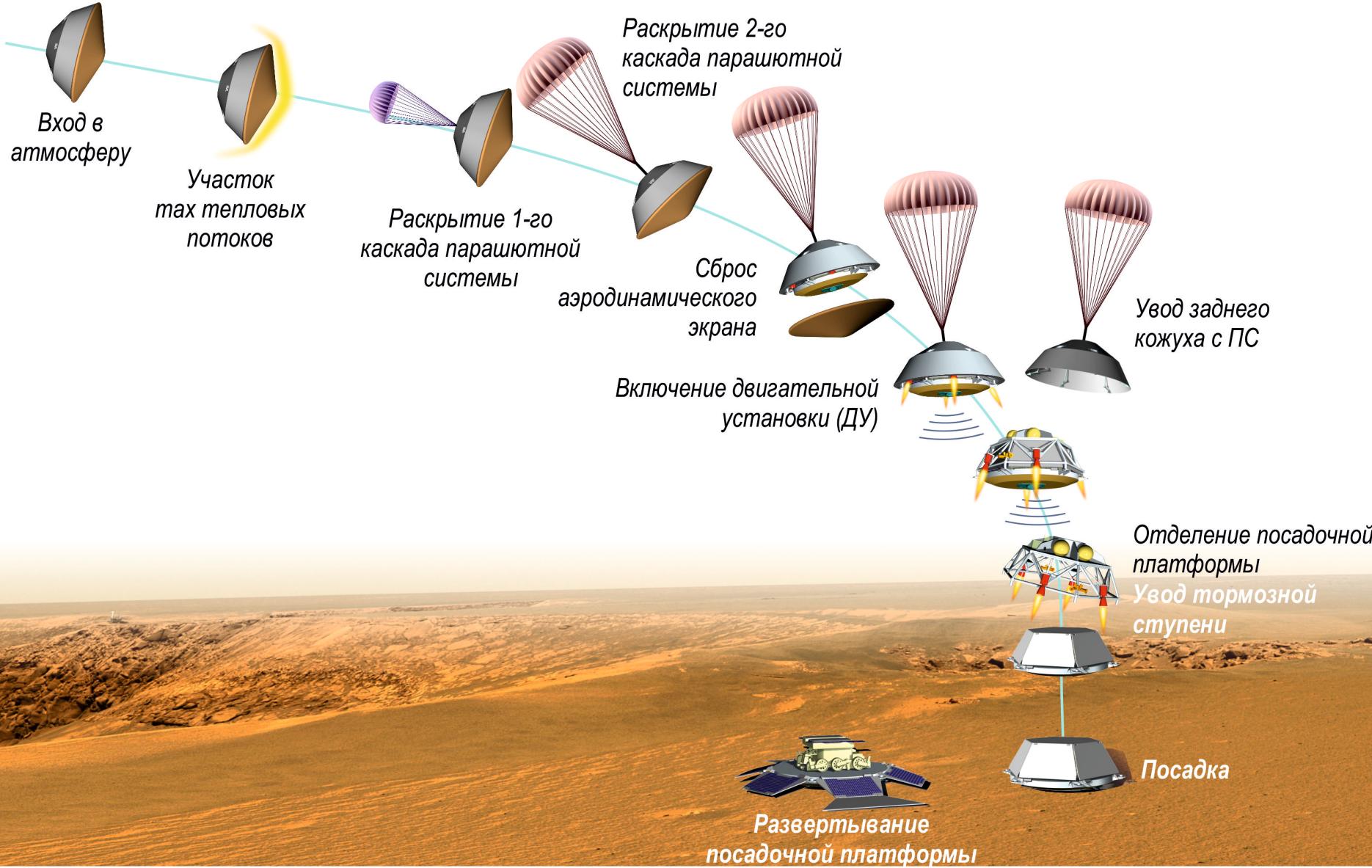


EXOMARS 2018: Descent Scenario 2



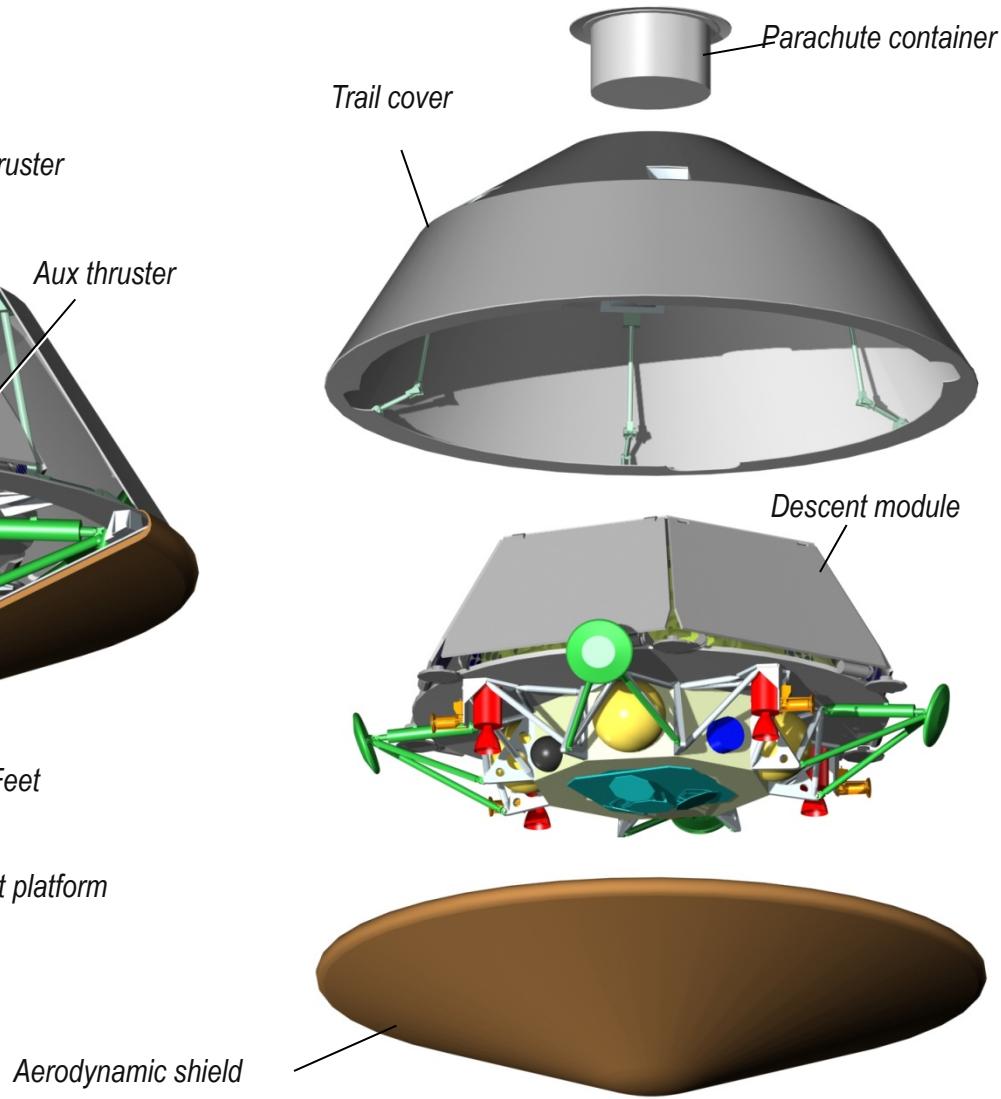
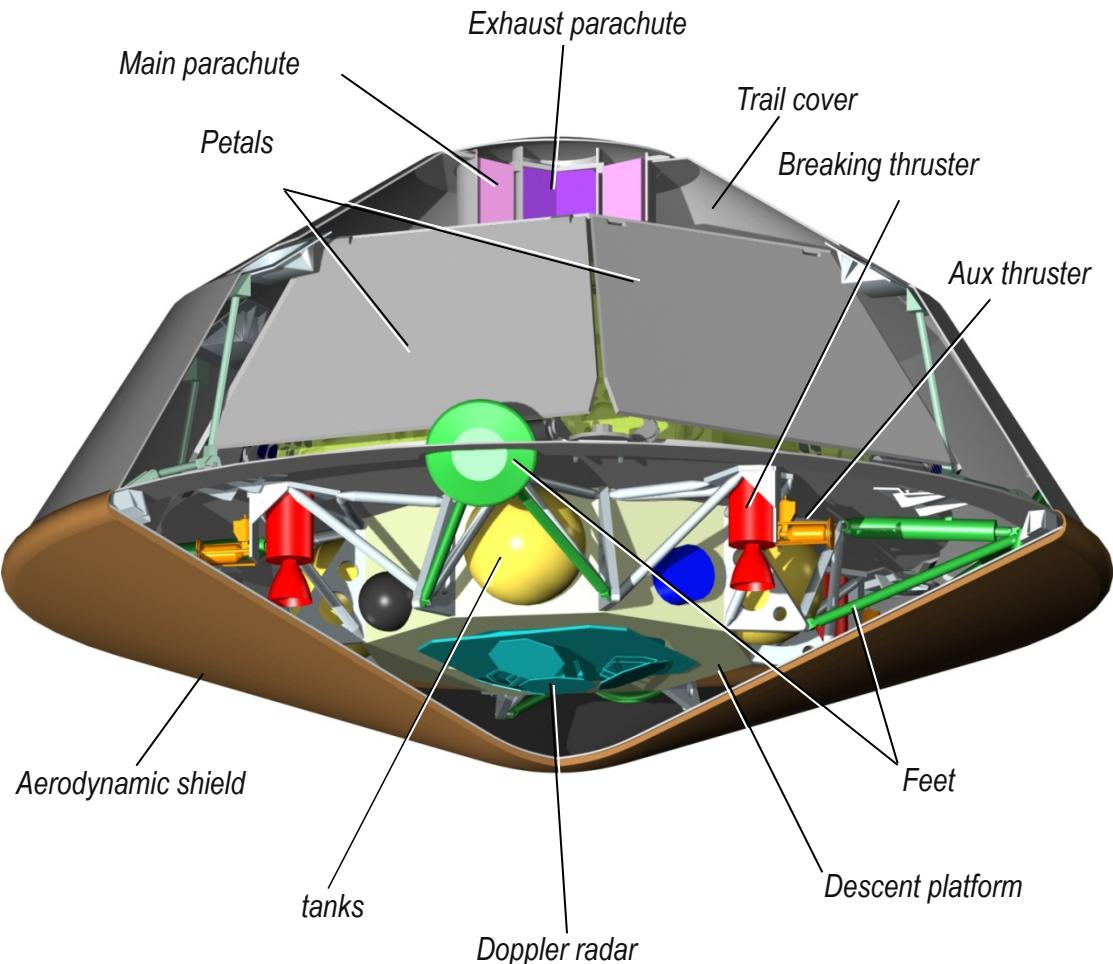


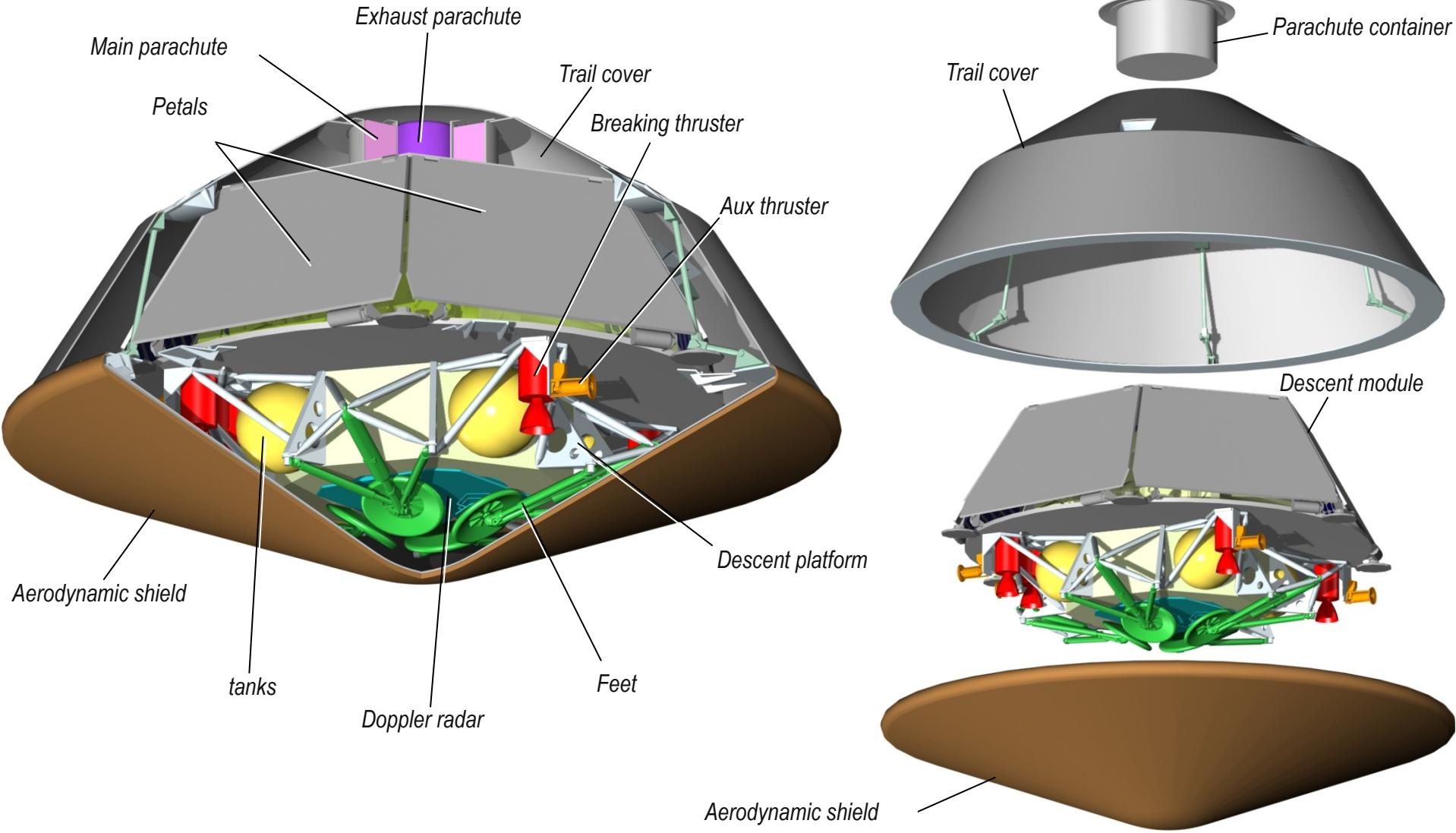
EXOMARS 2018: Descent Scenario 3





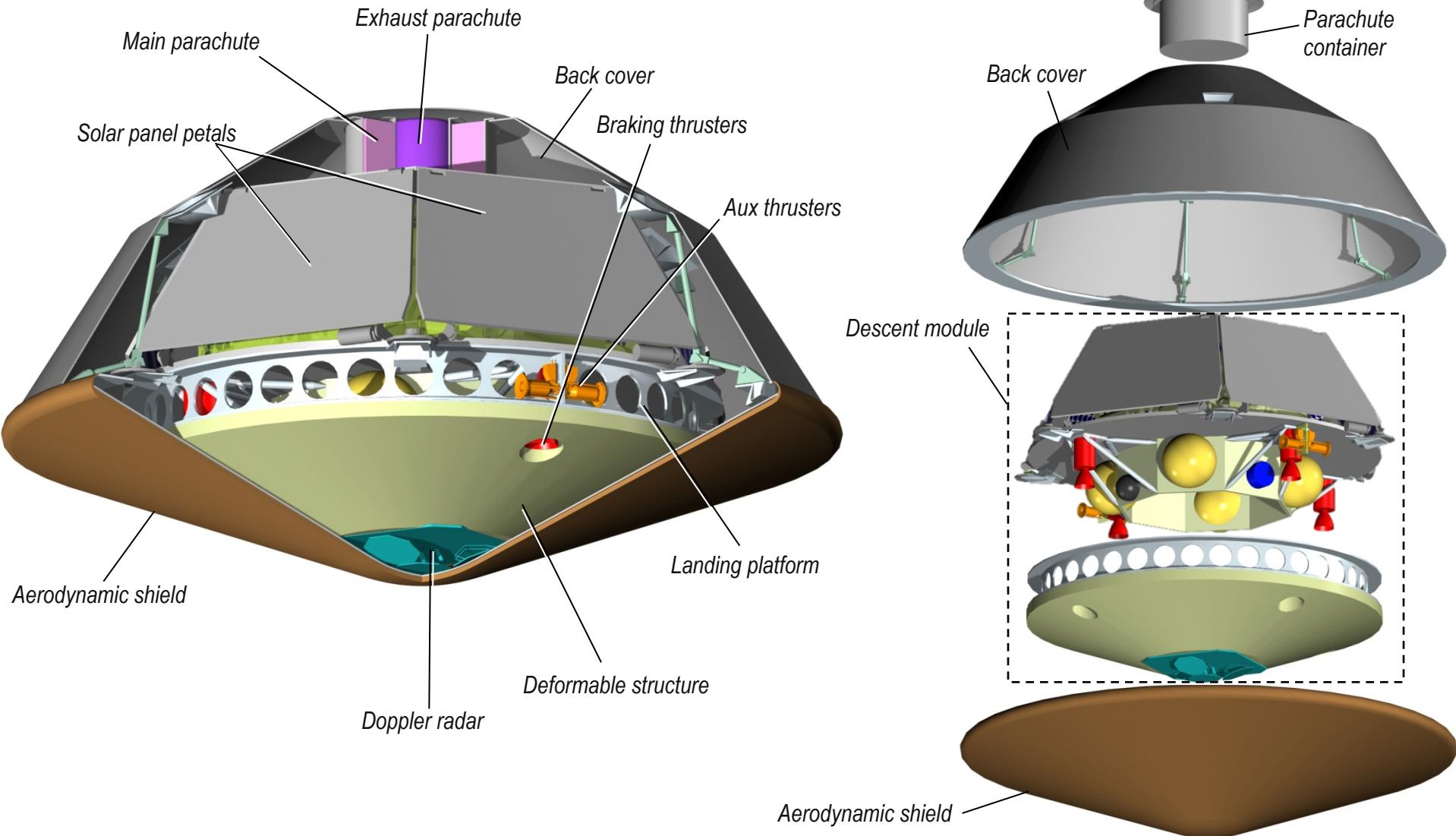
EXOMARS 2018: landing module integrated with braking stage





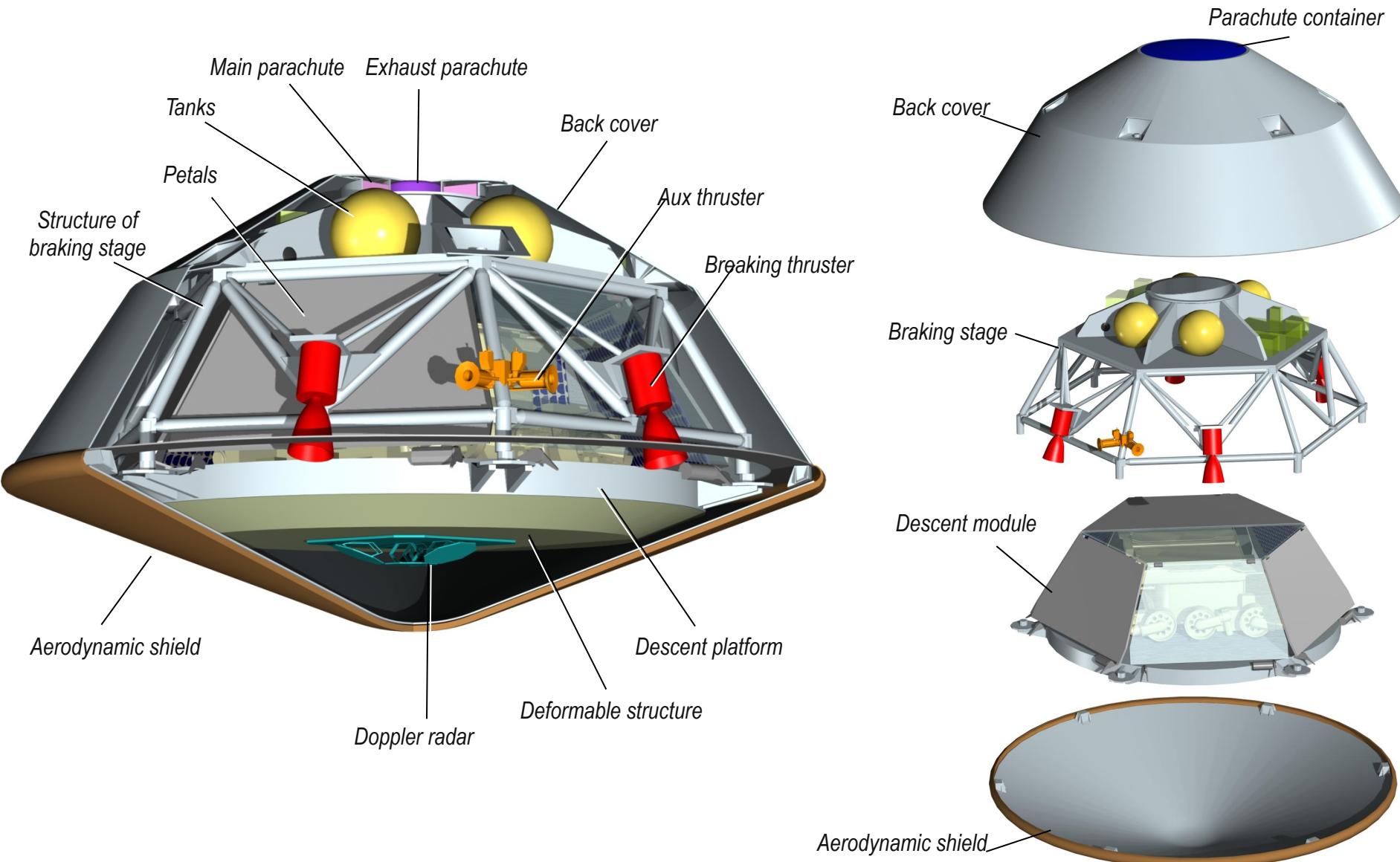


EXOMARS 2018: landing module integrated with braking stage and with deformable structure



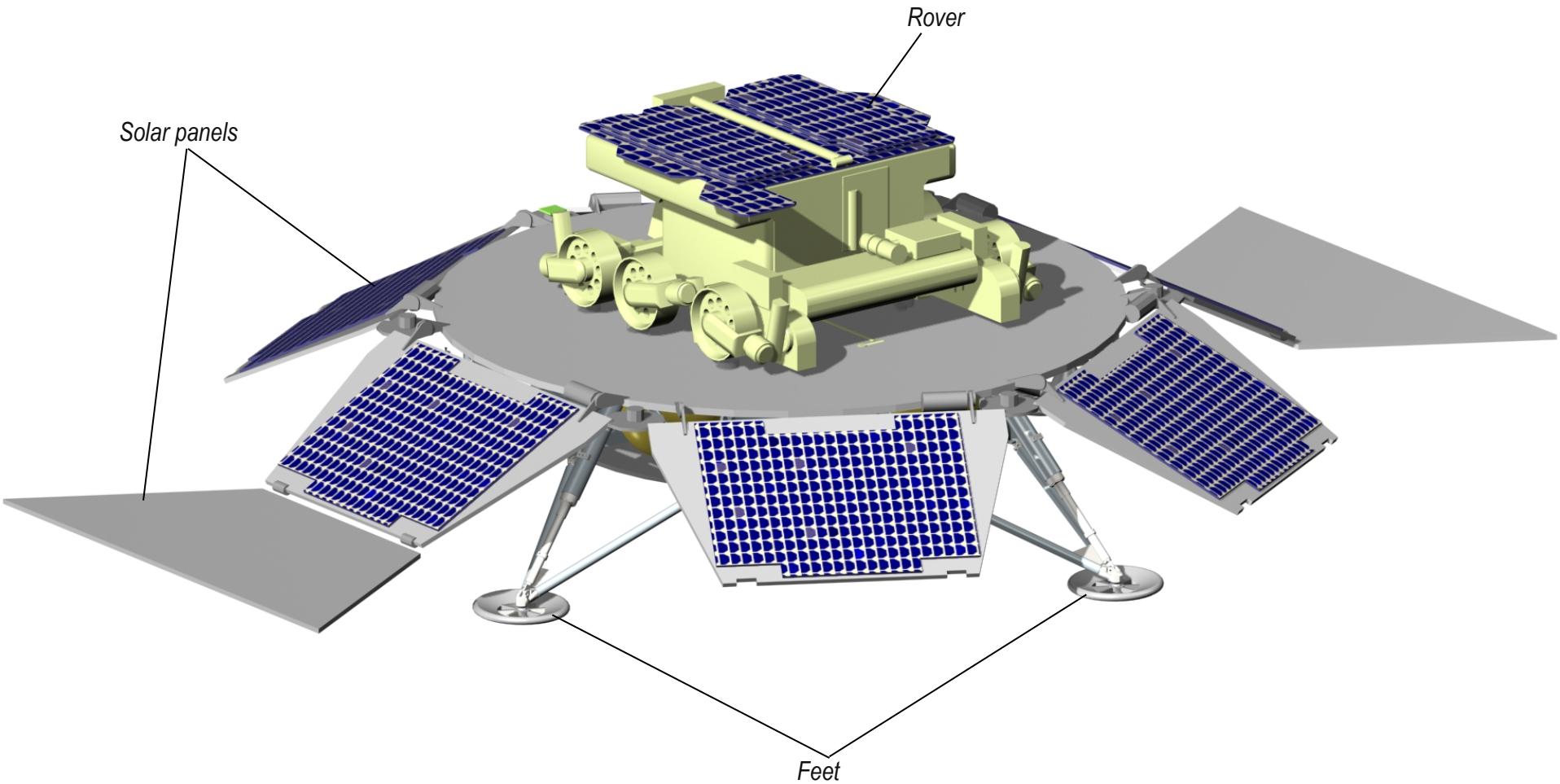


EXOMARS 2018: landing module separated from the braking stage





EXOMARS 2018: landing module in surface configuration





Exomars: landing platform

Preliminary instrument selection

Target mass of the science payload for the landing platform is ~50 kg. European contribution will be discussed once the level of resources available is confirmed. Preliminary list of scientific instruments:

Instrument	Mass	Description
Robotic arm w sampling device	3	Sampling for GCMS, close-up camera, Mossbauer
Meteopackage	3	PTW-Hum measurements
Moessbauer spectrometer	0.5	Iron mineralogy (Germany)
PanCam	0.4	Surface panorama, atmosphere
Methane detector (F-P spectrometer)	2.3	Methane, minor gases.
GSMS Gas chromatograph	10	Composition, reactivity
Seismometer	9.1	Seismometry (France)
STEM (contact sensors)	0.8	Temperature, conductivity, etc
Lidar	1	Aerosol up to 5-10 km
Fourier-spectrometer	3.8	Minor constituents, boundary layer (2.5- 25 µm)
M-TDLAS (laser spectrometer	0.5	Minor constituents, isotopic ratios locally
MARSES-MAIGRET (low-frequency radar, magnetometer	4	Water contents down to 100s of m, manetotelluric, etc
Neutron spectrometer	7.7	Subsurface water
MANAGA-TOF (atmospheric MS)	3.8	Atmosphere composition
Dust complex	4,5	Dust dynamics near the surface

Mission to Jupiter: Laplace-Europa

Lander (I):

Development:

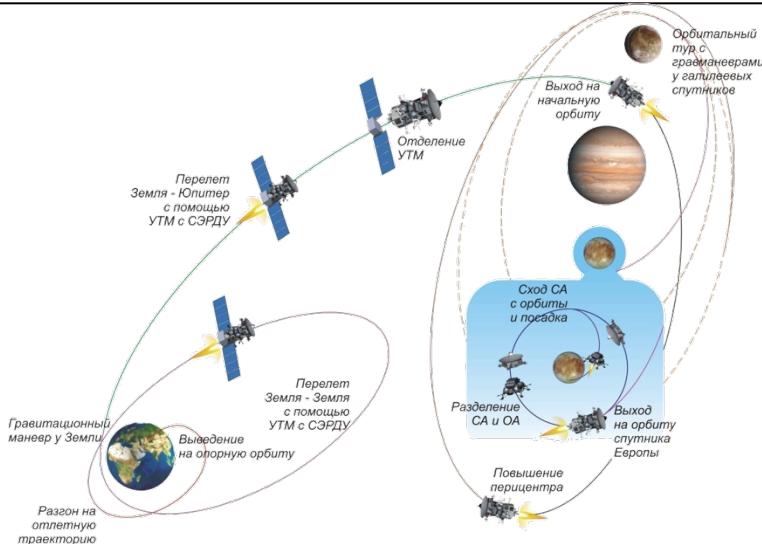
2008: Preliminary assessment

2008: Initial industrial study 2008

2009: Europa Lander workshop 2009

2010: radiation load/scenario/landing site assessment; lander payload definition

2011: further scenario development; orbiter payload definition; payload accommodation



Mission architecture:

- Europa lander, full mass 1210 kg, target 50 kg of mass for science
- Telecom and science orbiter, 50 kg science payload
- Multiple fly-bys of Ganimede, Callisto and Europa;
- Final circular orbit around Europa with a height of 100 km;
- Soft landing, target surface mission duration 60 days. Surface analysis by drilling (30 cm depth) possibly melting probe (<5 kg). Orbiter supports telecommunication. Optional TM directly to Earth via VLBI
- Target total radiation dose <100kRad behind 5 g/cm² Al (300 kRad tolerant components)

Laplace-Europa Lander (II):

Resources:

- 50 kg on the lander, including sample handling and (partially) radiation shield
- 3.2 kbit/s via HGA to 70-m dishes
- Lander data relay via orbiter
- 50 kg on the orbiter, including (partially) radiation shield

Proof-of-the-concept payloads

Lander:

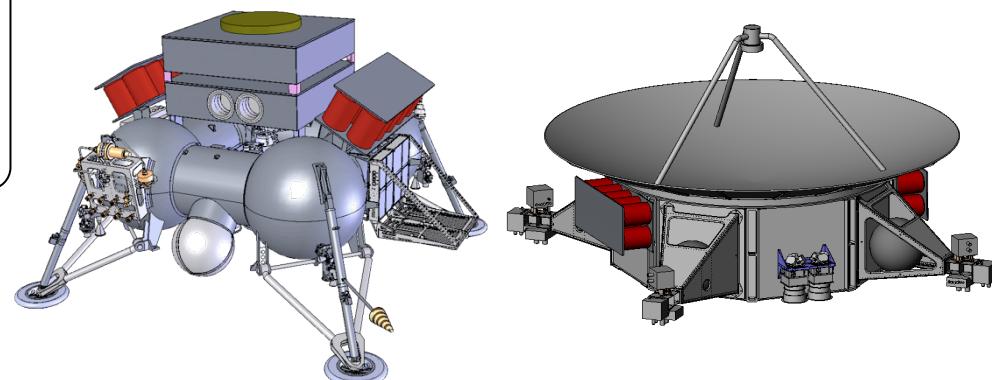
- 12 instruments → 20 kg
- 4-5 kg melting probe
- Drill for 30-cm depth

Orbiter:

- 6 instruments, incl. radioscience

Science Goals:

- The main appeal of the present mission is search for life on or its signatures on Europa
 - Sample acquisition, concentration
 - Subsurface access
- Establishing geophysical and chemical context
 - Biology-driven experiments should provide valuable information regardless of the biology results
- Lander is to provide ground truth for remote measurements and enhance the detection limits
- Orbiter: versatile remote observations; landing site characterization; Jupiter science

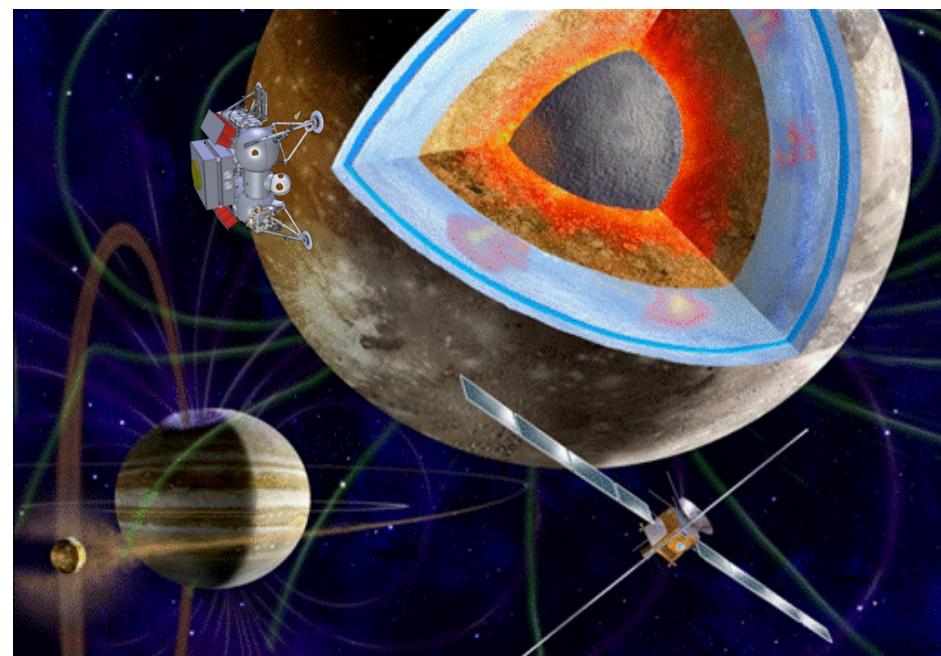


Europa or Ganymede ?

- Appeal of Europa with its largest ocean in Solar system and supposed interface with mineral mantle
 - Large radiation doses
 - Difficult implementation of property relaying and reconnaissance Orbiter together with the Lander
- ➔ Decision taken in 2011 to follow the JUICE for Ganymede

Strategic cooperation with ESA (2011-)

Selection of JUICE in 2012



Lines of JUICE-Ganymede Lander cooperation



1. Relaying of data from Ganymede Lander via JUICE orbiter
 - Coordination of mission scenarios
 - Technical compatibility issues
 - Coordination of science programme
 2. Real-time landing sites assessment and selection using JUICE imaging:
 - Coordination of mission scenarios
 - Coordination of science programme
- Alternative: landing using ESA visual navigation system
3. Symmetric participation in science payloads
 - JUICE instrument AO to be released in June, open for Russian instruments
 - ESA-member countries instruments at Ganymede Lander
 4. Launch of JUICE using Proton from Baikonur
- Implementation of RTGs

Europa Lander model payload



Instrument	Conditions	Composition	Habitability	Prototype	Mass (estimated)
Seismometer	●		○	OPTIMISM/Mars 96	495g +electronics
Magnetometer	●	○	○	MMO Bepi Colombo	770g
TV camera set	●	○	○	CIVA/Rosetta; Phobos 11	1200g
Optical microscope	●	●	○	Beagle-2; Phobos 11	300g
IR spectroscopy	●	●	○	No direct prototype; technique well established	(2000g)
IR close-up spectrometer	●	●	●	CIVA/Rosetta MicrOmega/ExoMars	(1000g)
GCMS	○	●	●	GAP/Phobos 11; COSAC/ Rosetta	(5000g)
Wet chemistry set (option 1)		●	●	Urey/ExoMars ¹	2000g
Immuno-arrays (option 2)		○	●	SOLID/ExoMars ¹	(1000g)
Raman spectroscopy	○	●	●	RAMAN-LIBS/ExoMars ¹	1100g ²
Laser-ablation MS	○	●	○	LASMA/Phobos 11	1000g
XRS (TBD)	○	●	●	No prototype	(2000g)
Various sensors	●	○	○	MUPUS/Rosetta	2350g
Radiation dose	●		○	RADOM/Chandrayaan-1	100g

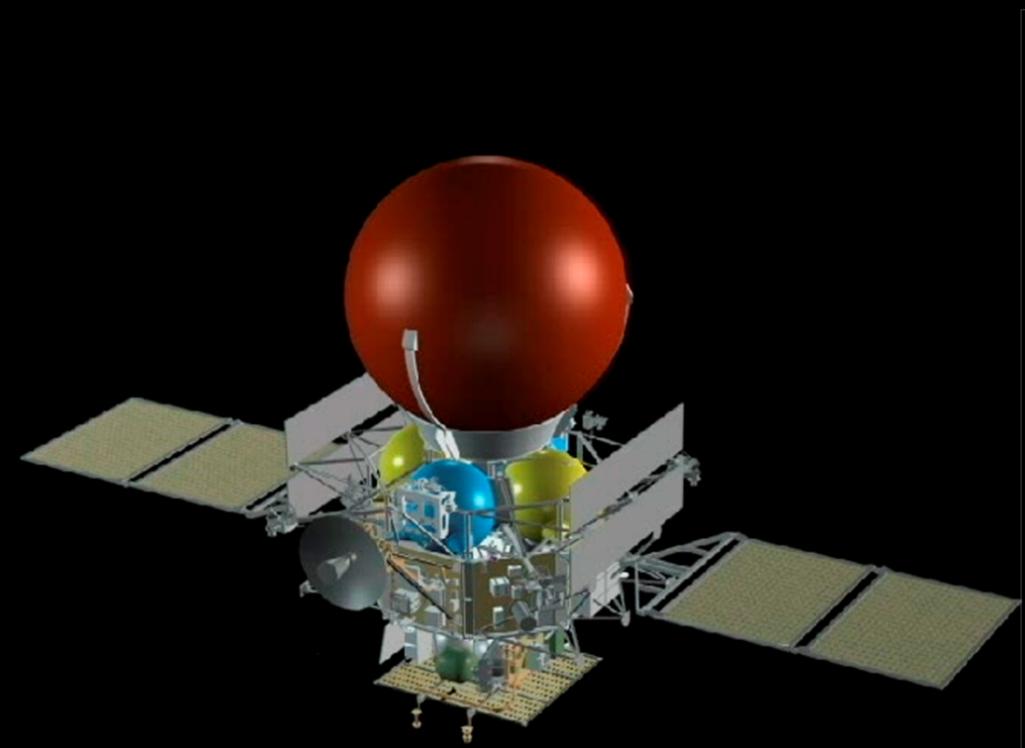
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Largely applicable to Ganymede?



Venera-D

- Lander: (VEGA-type, 2-3 h on the surface)
- Orbiter: (Phobos-Grunt-type, updated, 3y at 24-h orbit)
- Sub-satellite (48, 24, or 12-h orbits are considered)
- Considered for launch in 2024



CONCLUSIONS

MOON

1. The main attention is given to Lunar missions in 2015, 2016 and 2017
2. Cooperation with ESA is being discussed at system level for these missions and at mission level beyond (Lunokhod, Sample Return)

MARS

3. ExoMars becomes the core element of Mars exploration
4. Repeat of Phobos Sample Return is discussed for 2020-2022

JUPITER

5. Ganymede Lander in cooperation/coordination with ESA
6. Asteroid and Venus missions are possible after 2022

